DOCUMENT RESUME

ED 413 689 EC 305 958

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TITLE Effects of a Gluten-Free Diet on Rate of Learning in Autistic Children in an Applied Behavioral Analysis Program: Summary Analysis.
PUB DATE 1998-00-00
NOTE 35p.; For the first study, see ED 406 761.
PUB TYPE Reports - Research (143)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; *Autism; Behavior Change; Dietetics; Early Childhood Education; *Nutrition; *Outcomes of Treatment; *Performance Factors; Program Effectiveness
IDENTIFIERS *Gluten; *Nutritional Therapy

ABSTRACT

This summary analysis discusses a series of studies that used both between-subjects and within-subjects analyses to examine the effects of a gluten-free diet on the academic achievement of children with autism. In the first study, the between-subjects analysis included data from eight children with autism (ages 5-7), with four on a gluten-free diet and four controls. No significant achievement differences were found. The within-subjects analysis compared rates of achievement from 10 trials of three male participants before and 1 month after placement on a gluten-free diet. Analysis revealed a significant improvement in the rate of achievement following diet initiation. In the second study, six children (ages 4-7) with autism in an applied behavioral analysis program were divided into a gluten-free diet group and a control group. Those with a gluten-free diet showed significant improvement in the rate of learning. The third and fourth studies compared the performance of three of these children 6 months and 9 months after placement on a gluten-free diet. Results showed continuous improvement. However, the failure in study five to observe a significant performance change between the base line and the 9-month diet period, using either the between or within-subjects analyses, raises questions about the effectiveness of this treatment. (Contains 23 references.) (CR)

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ED 413 689

Effects of a Gluten-Free Diet on Rate of Learning in Autistic Children in an Applied Behavioral Analysis Program: Summary Analysis

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Abstract

Theorists postulate that improper metabolism of the proteins found in gluten gives rise to autistic symptoms. Due to this suspected link between allergies and the behavioral symptoms of autism, many families have eliminated gluten from their children's diets. Since implementing gluten-restrictive diets, many parents report observing drastic behavioral improvements in their children, including reduced aggression and increased compliance.

This series of investigation examined the effects of the gluten-free diet on learning in autistic children in an applied behavioral analysis program. Although significant interim effects were observed in Studies I, II, III, and IV, the summary analysis

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(Study V) failed to support the diet's efficacy.

The failure to observe a significant performance change over the 9 month diet period, using either the within or between-subjects analysis, raises questions about the reliability of this treatment's effectiveness. Further research is needed to clarify the long-term impact of the gluten-free diet on the performance of autistic children.

Introduction

Autism is a neurological disorder marked by severe impairment in social, emotional, and intellectual functioning. Autistic syndromes are variously referred to as childhood autism, infantile autism, autistic disorder, pervasive developmental disorder, and childhood psychosis. The basic criteria include abnormal social relatedness, abnormality of communication development, repetitive patterns of behavior, and abnormal stimuli responses (Edelson, 1997). Autistic individuals also have difficulty in seeking comfort, imitating others, and participating in imaginative activities.

Etiology

The cause of autism is still unknown; however, there are varied theories as to what induces this behavioral syndrome. One theory postulates a genetic factor in autism, and there is supportive research evidence showing higher concordance among monozygotic twins than dizygotic twins. If the main causes are environmental, then the concordance rate should be the same for both types of twins. Biological children of autistic individuals are at increased risk for the disorder. Researchers in Utah examined 11 families in which the father had autism, and out of the 44 offspring, 25 of the children had autism or autistic tendencies (Edelson, 1997). Autism occurs in siblings of autistic children 2.7% of the time, and autistic traits will often show up mildly in the parents, siblings, and other relatives of the autistic child (Wolf-Schein, 1997; Noreen et al., 1990; Landa et al., 1992).

Children with autism also have structural abnormalities in their brains. The limbic system is immature, which causes problems with emotions, aggression, and learning. The transmission of nerve impulses through the brain is also abnormally slow (McClelland et al., 1993). Courchesne (1995)
found two areas of the cerebellar vermis to be extremely small in 86% of autistic subjects and abnormally large in 12% of autistic subjects. Due to these abnormalities, the children may have deficient ability to focus their attention to follow the verbal cues that signal changes in social communication (Wolf-Schein, 1997).

Autistic individuals also differ from others in terms of neurotransmitter activity. Research suggests that they have unusually high levels of serotonin and beta-endorphins (Panksepp, 1979). The fact that autistic children appear to have a higher pain threshold could be due to these elevated levels of beta-endorphins, which are opiate-like substances in the body that allow tolerance of pain .

There is also evidence consistent with a possible viral etiology. If a female is exposed to rubella during her first trimester of pregnancy, then she has an increased risk of having of child with autism (Edelson, 1997).

Concerns about environmental precursors to autism include the possible effects of toxins and pollution on the developing child. In Leomenster, Massachusetts, there is a high prevalence of autism surrounding a particular manufacturing factory. The highest

percentage of cases were found in the homes down wind from the plant smokestacks (Edelson, 1997).

Cognitive conceptualizations of autism see the disorder as a defect impairing the highest level of cognitive processing (Frith, 1993; Wolf-Schein, 1996). This defect results in autistic children not being able to think about mental states, such as beliefs and the perspective of others (Baron-Cohen, Lesile & Frith, 1986). When autistic children were handed pictures of people to sequence, they did poorly because in order to complete the sequence correctly they had to comprehend the beliefs of others.

Autism has also been viewed as a psychosocial/ psychogenic disorder with a basis in family relationships. This etiological perspective generally places the blame on the parents of the child, and claims the child must have experienced extreme, unconscious, emotional mistreatment as an infant (Wolf-Schein, 1996).

A more recent theory on the cause of autism concentrates on a link between allergies and behaviors. Autistic children have metabolic difficulties with gluten or wheat products, and casein or milk products. Research theorists have proposed that abnormal functioning of opioid peptides promote the emergence of autistic symptoms. Analysis of 24 hour urine samples from children with autism have shown increased levels of peptides (Reichelt et al., 1986). These peptides, which are short chains of amino acids, derive from the incomplete digestion of gluten, which breaks down into gluteomorphins, and of casein, which breaks down into casomorphine. For most people, the digestion of proteins occurs

through the intestines, however, for the autistic child this digestion is incomplete and results in the characteristic traits of the disorder. Most of the peptides are released through the urine, but a small amount still manage to escape into the blood stream and cross into the brain, which is hypothesized to alter normal brain transmission (Lewis, 1994).

Gluten-Free Diet

After researchers discovered the possible contribution that gluten made to autistic symptoms, many families removed gluten from their children's diet. Glutens are proteins found in plants which are members of the grass family, including wheat, oats, barley, rye, tritical, and their derivatives (Lewis, 1994). Several preconditions must be met for the diet to have a successful impact, including (1)the dietary intervention should be effective, (2)active peptides should be formed in the gut, (3)the uptake of peptides and proteins from the gut takes place, (4)the compounds are found in the urine, (5)the compounds pass the blood brain barrier, (6)the genetic disposition should be compatible with the peptide aetiology, (7)the peptides produces autistic effects, and (8)immunological effects occur (Reichelt, Knivsberg, Reichelt, & Nodiand, 1996).

The beginning of the 1980's provided the first evidence that similarities exist between the behavior of animals on opioids and the symptoms of autism. Panksepp (1979) suggested that autistic individuals may have elevated levels of opioids, such as beta-endorphins. In 1986, Reichelt analyzed the urine samples of 24 autistic children, and found increased levels of peptides.

Following this observation, in 1988, Gillberg produced evidence of elevated levels of opioids in the cerebro-spinal fluid of autistic individuals (Lewis, 1994).

Autistic children were analyzed in 1990 by Reichelt and treated with either gluten-free and casein reduced or casein-free and gluten reduced diets. Of the 15 participants, 5 had increased levels of antibodies to casein or gluten. The diet allowed for the decrease in urinary peptide secretion, and the improvement in several behavioral areas, including a decrease in seizures (Reichelt, 1990).

Knivsberg et al. (1995) have provided initial results on a study of a gluten-free diet as a treatment for autism. The diet was applied to 15 subjects with autistic syndromes. All the children participating had an increased level of peptides in their 24 hour urine samples and had pathological urine patterns. The child participants were given behavioral, psycholinguistic, and cognitive tests before they started the diet and one year later.

After the first year of the diet, the children were communicating and responding more actively. They experienced a greater ease with emotional expression and with the formation of social relationships with other children. Appropriate play increased, while odd movements, fear, and avoidance of physical contact decreased. Also the urine samples were tested after one year and revealed normal urine patterns and peptide levels. Language was assessed via administration of the Illinois Test of Psycholinguistic Abilities (ITPA). All subscales, except for short

term memory, increased after the first year of the diet. A measurement of cognitive ability showed that the children used their cognitive abilities in a different way when they were on the diet. Parents and teachers observed a change in the children's motor abilities, due to a new awareness of their bodies. Bladder control increased, and their high pain threshold decreased.

Knivsberg et al.(1997) also performed a study on the effect of the dietary intervention after four years. The researchers looked at the original group of child participants placed on the gluten and casein free diet. The children who remained on the diet after the initial year continued to develop, while those who discontinued the dietary intervention regressed. The Illinois Test of Psycholinguistic Ability scores increased beyond the expected level. When comparing the scores from the first year with those from the four year follow-up, similar profiles were displayed by the children however at higher functional levels. After four years there was improved social interaction, less social isolation, more communicative ability, and a decrease in peptide levels (Knivsberg et al., 1997)

The urinary samples of children diagnosed with autism syndromes, from several different countries, were also analyzed by Knivsberg (1997). The peptide excretion was examined by a new HPLC method, and showed that the amount was statistically the same among all nationalities. When the gluten and casein were removed from the diet of these children, they showed demonstrable improvements on different tests (Knivsberg et al., 1997).

Many families who have experienced their child going through the diet initially report that the child's behavior regresses during the beginning stages of the gluten-free diet. Some negative effects reported include upset stomach, bad temper, and clinginess. A period of one year is suggested to see if the diet is working, however, most likely after three months if a gluten-free diet has not produced results, it will not. For the children who improve due to this diet, the restriction of gluten is highly worth the sacrifice. For most, aggressive tendencies cease and communication and socialization expands. It is generally assumed that these functional changes were due to direct or indirect modifications in the pharmacological effects of the peptides, produced by reduced exposure to gluten (Knivsberg et al., 1995). The link between allergies and behaviors has begun to receive a great deal of attention, not just as an intervention tool but also as a possible preventive measure. The diet however should not be a substitute for a previous treatment method, but rather a supplement and additional tool (Knivsberg et al, 1995).

Behavioral Analysis

The literature on autism contains numerous etiological hypotheses and there is no certainty as to which model best accounts for this severe impairment. Therefore, several competing intervention strategies have emerged over the years. A majority of these interventions have met limited long term success (DeMeyer, Hingten, & Jackson, 1981; McEachin, Smith & Lovaas, 1993). Research, however, has shown that functioning has improved for

autistic children following intensive behavioral intervention (Lovaas, 1987; McEachin et al, 1993). The applied behavioral analysis program, developed by O. Ivar Lovaas, has produced favorable and long-lasting results, and has been reported as having the best outcomes among all current methods (CSAAC, 1997).

The outcomes of O. Ivar Lovaas indicate 47% of the children who participate in this intensive intervention program will achieve normal IQ and educational placement evaluations. The children who are unable to achieve the normal intellectual levels still improve in general intellectual areas. Even the smallest improvement for these children allows learning to take place in less restrictive environments and classrooms (CSAAC, 1997).

Dr. Theodore Shapiro and Dr. Margaret Hertzig (1995) of the New York Hospital-Cornell Medical Center, claim that the outcomes of this method are astonishing. After two siblings took part in the applied behavioral analysis program of Dr. O. Ivar Lovaas, they no longer fit the diagnostic criteria for autism and they no longer displayed the social, personal, and language difficulties that accompany this disorder.

A study examining the long term outcome for autistic children who had received early intervention behavioral treatment revealed evidence of continued achievement over time, and significant enduring intellectual gains (McEachin, Smith, & Lovaas, 1993). These researchers took a group of 19 autistic children, under the age of four years old, and provided them with forty hours of behavioral treatment for two years. When the children reached the

age of seven, they were re-evaluated. The children had gained an average of 20 IQ points, and nine out of the nineteen had completed first grade. The control group for the study consisted of forty untreated autistic children. When re-evaluated, only one out of the forty control group participants had reached a normal level of intellectual functioning. The results of the study showed that those who had received the early intervention continued to surpass members of the control group (McEachin, Smith,& Lovaas, 1993).

This behavioral approach is now considered to be the most popular and effective educational treatment for autism. This treatment provides concrete criteria for measuring skill mastery. Behavior of children participating in this treatment is evaluated systematically, permitting detection of subtle changes in the rate of achievement over time.

The discrete trial is the basic three-part teaching unit used in the applied behavioral analysis program to maximize learning in developmentally disabled children. The discrete trial consists of the discriminative stimulus, the response, and the reinforcing stimulus. Through the use of these trials, along with reinforcement, prompting, and shaping, this program allows the modification of unwanted behaviors. The approach itself includes procedures that emphasize behavior enhancement and behavior reduction (Campbell, Schopler, Cueva, & Hallin, 1996). A central belief of this method is that reinforcement that enhances or reduces the behaviors should be contingent upon the behavior targeted. Therefore, the child should not be able to obtain the

reward through other means or at other times besides therapy.

In order for a specific treatment plan to be created for the child, a detailed analysis of the relationship between the child and the environment takes place. From this point, the drills are chosen in order to strengthen or eliminate particular behaviors.

This behavioral treatment is extremely time consuming, and involves both the participation of family members and competent therapists. Overall, this early intervention program is aimed at enhancing the intellectual and social skills of these children so that they will be able to take care of themselves as they grow older, and have adequate socialization opportunities along the way(Niemann, 1994).

The Search for New Treatment Strategies

Even though the advantages of the behavioral treatment are numerous, the families of these children still search for additional means of dealing with this neurological disorder. They are constantly engaged in a desperate search for any new method that claims to work. The parents will turn to various types of traditional and non-traditional treatments in the hope of increasing their youngster's appropriate behaviors.

Other intervention methods include: language and communication therapy, and auditory integration training. The two treatments which have received the majority of empirical support are behavior modification and the use of the vitamin B6 with magnesium supplements. However, the more controversial means of intervention include the use Ritalin and facilitated communication. Ritalin is

the most widely prescribed medication for autistic children, however, because there have been no double blind controlled studies, it is difficult to verify its effectiveness (Edelson, 1997). Facilitated communication is considered unorthodox, but has attracted many adherents. With this method the non-verbal child is given a means of communication, however it is unknown who is actually doing the communicating, the child or the facilitator.

Facilitated Communication

The research literature on facilitated communication illustrates the vulnerability of the autistic population to oversold, unsubstantiated treatment methods. With the emergence of facilitated communication in the 1970's came the hope that a miracle tool with startling results had been discovered. Previously nonverbal autistic children, with the help of a facilitator, were now apparently typing words and sentences with clarity and intellect. Once it arrived in the United States in the early 90's, families seized upon it, even though well-controlled efficacy studies had not yet been performed.

Behind the idea of facilitated communication is the belief that autistic individuals have literacy and intellectual abilities, but are unable to utilize them due to their disabilities (Biklen, 1990; Biklen & Schubert, 1991; Cardinal, Hanson, & Wakeham, 1996). By means of facilitated communication, these masked competencies are assumed to be demonstrated. This method requires that a facilitator physically supports the hand, wrist, or arm of the individual, so that they can select particular pictures, words, or

letters on the keyboard or alphabet board. This facilitation is hypothesized to allow the individual to communicate effectively (Weiss, Wagner, & Bauman, 1996).

During the early stages of using facilitation, the individual is completely dependent on the facilitator for stability and reliability of selections. However, as time progresses, the objective is to reduce this support. Eventually, the individual should be able to control their hand movements and independently make selections on the keyboard (Lapos, 1996).

Much of the debate revolving around facilitated communication concerns whether autistic subjects are actually the source of the message conveyed. Controlled research using double and single blind procedures have shown that without the assistance of the facilitator, the disabled individual is unable to respond accurately. Therefore it can be assumed that the responses are actually controlled by facilitators and not in fact by the disabled individuals.

Wheeler, Jacobson, Paglieri, and Schwartz (1993) took 12 autistic individuals competent in facilitated communication and assessed if the facilitators were unknowingly determining what was typed. Three conditions existed. The first condition allowed for assisted typing with the facilitator unaware of the stimulus content and the second involved unassisted typing. The third involved assisted typing with paired pictures that were unknowingly presented either the same or different to the participant and facilitator.

Out of the 180 trials there were no clear correct responses. During the trials in which the facilitator and the participant received different stimulus cards, there were 12 responses correct to the cards shown to the facilitator and 0 responses correct to the participants cards. Vazquez (1994) found similar results when she tested the validity of facilitated communication while controlling for cuing. She concluded that the correct answers were typed only when the facilitator knew the answer. When controlled quantitative studies are performed, rather than qualitative studies, the results seem to be consistently negative and indicate that this method is not valid (Jacobson, Mulik, & Schwartz, 1995).

Another issue facing facilitated supporters of communication involves the potential misuse of the process. Following facilitated communication, many families have been confronted with allegations of sexual abuse or molestation of the disabled child. The facilitators believe they have come across evidence of abuse, and report the families to the authorities. A majority of the time the cases are terminated before extended prosecution or trial. Investigations usually show that the facilitator was influencing the communication, and that there was no factual basis for the charges.

Despite the negative outcomes and misuse, a few studies have demonstrated that facilitated communication can for some individuals be a valid form of treatment. An autistic individual took part in three independent trials, with the help of an uninformed facilitator. After the reading of short stories, the

validation procedure took place. In two of the trials, the autistic individual answered specific questions correctly and accurately with the help of an uninformed facilitator (Weiss et al., 1996).

Another study involved over 3000 severely disabled students, in an attempt to validate facilitated communication under controlled, blind conditions. The students were asked to spell words while the facilitator was absent. The students were allowed to practice the test but not the actual words. Six weeks later, 74% of the students could correctly spell one or more of the words shown to them while the facilitator was absent, and half were able to spell two to five words. These results proved to be remarkable; with out facilitation these disabled individuals were able to reach high performance levels only after nine sessions (Cardinal, Hanson, and Wakeham, 1996).

Overall, facilitated communication research indicates that the facilitator may unwittingly be selecting the letters to spell out the particular message. The authorship is often in the hands of the facilitator, and not the disabled individual. Without the facilitator present, few advances have been made.

The initial acceptance of this treatment method prior to suitable outcome evaluation is alarming. Families must learn that treatment failures and shams exist. Due to their susceptibility, it is clearly possible that families of autistic children can be exploited by those eager to oversell untested treatment methods.

Empirically Validating The Gluten-Free Diet

Unlike the controversial method of facilitated communication, many outcome evaluations have been done concerning the effects of the gluten-free diet. The gluten- free diet has been shown to increase the autistic individual's psycholinguistic and cognitive skills. It therefore seems reasonable that this same diet would increase the behavioral achievement of the autistic individual. Applied behavioral analysis is viewed as one of the most effective approaches to this disorder. This treatment provides concrete criteria for measuring skill mastery. Behavior of children participating in this treatment is evaluated systematically, which allows for the detection of subtle changes in learning rates. For these reasons, children receiving applied behavioral analysis were used in the present studies.

Study 1

Method

Subjects

Eight autistic children, with ages ranging from 5 to 7 years served as subjects. Four of the subjects were on a gluten-free diet, and the remaining four served as controls. Placement into the gluten-free group was at parental discretion. Control group subjects were selected in order to match for age and length of time in the treatment.

Procedure

For the between-subjects analysis, each subject's five most recently mastered behavioral skills, called targets, were included. For each target, the number of attempts at mastery before the

criterion was achieved was recorded. The total number of attempts for the five targets comprised the dependent measure for each participant.

The within-subjects analysis compared rates of achievement of five behavioral targets of 3 male participants, before and 1 month after the start of the gluten-free diet. The total number of attempts for the last five targets mastered before the diet was administered comprised the pretreatment score for each participant. The total number of attempts for the first five targets mastered following 1 month on the gluten-free diet served as the post-treatment measure.

Results

For Study 1, a one-way t-test was used to compare the rate of mastery of the group of children placed on the gluten-free diet with that of the matched control group, in order to determine if a gluten-free diet significantly increased the rate of behavioral learning. This between-subjects analysis revealed no significant group difference in rate of achievement ($t=-1.10$, $df=20$).

Because substantial within group variability was noted, a within-subjects t-test was performed on the pretreatment and post-treatment measures of children on the gluten-free diet in order to provide a more sensitive measure of the effects of the diet on rate of learning. This within-subjects analysis indicated a significant increase in rate of achievement following the implementation of the gluten-free diet ($t=2.306$, $p<.05$, $df=14$).

Discussion

Results of this preliminary study are inconsistent. While the within-subjects analysis indicated that a gluten-free diet significantly improves the rate of learning, the between-subjects assessment provided no such evidence of treatment efficacy. Substantial within-group variability may have made the between-group design insensitive to the subtle changes associated with the gluten-free diet. The within-subjects design permits each subject to in effect serve as their own control, which seems to have afforded a more sensitive assessment of change. However, the exceedingly small number of subjects in the within-subjects analysis compels caution in drawing conclusions from this analysis. Extensions of this study, using a larger sample of children on the gluten-free diet are clearly needed. In addition, this within-subjects design is marred by confounding of treatment effects by time effects. It is conceivable that the observed improvement in the rate of learning may have been due to the effects of time and experience, rather than a function of the gluten-free diet. There is a reasonable possibility that the rate of learning would have increased over time regardless of diet. Future pre-post studies should include a matched control group, to determine if any observed increase in rate of learning can be attributed to experience or time effects.

A further complication in this type of efficacy research involves confounds arising from the self-selection of families using a gluten-free diet. It seems plausible that parents who are willing to invest the considerable time and effort needed to

sustain a gluten-free diet are devoting more energy to enhancing their children's functioning than other parents of autistic children. Often parents using the gluten-free diet are simultaneously experimenting with many other available treatments, which, in combination, may yield an improvement in rate of learning. A double-blind design, with random assignment of children to the gluten-free diet and control groups would alleviate this problem.

Study 1 yielded conflicting results. Future research using a larger sample of youngsters placed on the gluten-restriction diet may help to clarify the efficacy of this intervention method. Until further results are obtained, it is not reasonable to state that a gluten-free diet significantly increases rate of learning of autistic children participating in a behavior modification program. Because of the considerable difficulties associated with maintaining this diet, confounding factors should be eliminated from studies before their results are used as a basis for recommending that parents in general implement this diet with their autistic children.

Study 2

Method

Subjects

Six autistic children, with ages ranging from four to seven years old, served as subjects. Subjects' parents signed an informed consent form to indicate that participation was voluntary.

All subjects were participating in a formal applied behavioral analysis program using identical criteria for skill mastery. Three subjects, with an average age of 5.6 years and with an average of 1.6 years experience in applied behavioral analysis, were on a gluten-free diet. The remaining three subjects, with an average age of 5.3 years and with an average of 1.4 years experience in applied behavioral analysis, served as controls. Placement into the gluten-free group was at parental discretion. Control group subjects were selected in order to match for age and length of time in the treatment.

Procedure

The within-subjects analysis of Study 1 was marred by the confound of treatment effects by time effects, so Study 2 included a matched control group to determine if any observed increase in the rate of learning can be attributed to time or practice effects. For the control group, rates of learning of five behavioral targets of one female and two male participants were recorded at the beginning and end of a one month time period. These rates were also compared using a within-subjects analysis. The total number of attempts required to master the last five targets at the beginning of the designated one month time period were compared to the total number of attempts required to master the first five targets at the end of the one month time period.

Results

Within-subjects t-test was performed on the pretreatment and posttreatment measures of rate of learning of children on the

gluten-free diet. The within-subjects analysis indicated a significant improvement in the rate of learning following implementation of the gluten-free diet ($t=2.306$, $p<.05$, $df=14$).

For the control group, a within-subjects t-test was performed on the measure of rate of learning at the beginning and end of the one month time period. This within-subjects analysis indicated that there was no significant increase in the rate of learning over the one month time period ($t=1.178$, $df=14$).

Discussion

The results of this study indicate that a gluten-free diet is associated with a significant improvement in the rate of learning of autistic children participating in an applied behavioral analysis program. This study controlled for the possible confounding of treatment effects by time effects. Thus, the observed increase seen in the gluten-free group cannot be attributed simply to experience in the applied behavioral analysis program.

However, the exceedingly small number of subjects in both of the groups compels caution in drawing the conclusion that a gluten-free diet increases the rate of learning of autistic children. Extensions of this study, using a larger sample size, are clearly needed.

Study 2 is vulnerable to some of the same concerns raised previously about Study 1. A further limitation in this type of naturalistic efficacy research involves confounds arising from the self-selection of families using a particular treatment, such as a

gluten-free diet. It seems reasonable to assume that parents who invest the considerable time and effort needed to sustain a gluten-free diet may also be devoting more energy, in other ways, to enhancing their children's functioning than other parents of autistic children. Since parents using the gluten-free diet are often simultaneously experimenting with many other available treatments, observed improvement cannot singularly be attributed to the diet. A double-blind design with random assignment of children to the gluten-free diet and control groups would alleviate this problem, but obviously this design presents serous practical and ethical problems.

The present study yielded results indicating that a gluten-free diet may significantly increase the rate of learning of autistic children in an applied behavioral analysis program. Future research using a larger sample of youngsters placed on the gluten restriction diet may help to clarify the efficacy of this intervention method. Until further research is conducted, it is reasonable to tentatively state that a gluten-free diet significantly increases rate of learning of autistic children participating in an applied behavioral analysis program.

Study 3

Method

Subjects

Three autistic children, with ages ranging from five to seven years old, served as subjects. All subjects were also participants in the prior studies on the effects of the

rate of learning on autistic children in an applied behavioral analysis program. The three subjects on the gluten-free diet had an average age of 6.4 years and an average of 1.8 years experience in an applied behavioral analysis program.

Procedure

Rates of learning of five behavioral targets of three male participants, 3-months and 6-months after the start of the diet, were compared using a between-subjects analysis. The total number of attempts for the last five targets mastered following 3-months and 6-months, on the gluten-free diet comprised the post-treatment scores for each participant.

Results

In study 3, the between-subjects analysis showed additional enhancement of learning after 6-months on the diet. The between-subjects analysis compared the performance of participants after 3-months on the diet and after 6-months on the diet. Significant differences in scores were found when the two groups were compared ($t=1.82$, $df=28$, $p<.05$). The mean number of trials to mastery at three months was 24.1 with a standard deviation of 11.82. The mean number of trials to mastery at six months was 15.86 with a standard deviation of 13.22. The 6-month scores were significantly better than the 3-month scores, suggesting that additional time on the diet continued to enhance performance.

Discussion

The results of this study indicate that a gluten-free diet is associated with continual improvement in the rate of learning of

autistic children participating in an applied behavioral analysis program over a time period of 6-months. The dietary restriction of gluten may produce additional improvements over time, at least during the first year of exposure.

Because only three subjects were used for the present study, caution should be used in drawing general conclusions. Extensions of this study, using a larger sample size, are clearly needed.

A further limitation involves confounds from the self selection of families using the gluten-free diet. Parents who invest the considerable time and effort needed to sustain a gluten-free diet may also be devoting more energy in other ways, to enhancing their children's functioning than other parents of autistic children (Gemmell & Chambliss, 1997). The present extension suggested that the benefits the diet produces are enhanced over time. This could be due to a physiological variable or to positive changes in family expectations and strategies.

Further research should be done on the children at later times following the intervention. Regular evaluations need to be included in the gluten-free diet to see if further improvements develop over time.

Study 4

Methods

Subjects

Three autistic children, with ages ranging from five to eight years old, served as subjects. All subjects were also participants in the three prior studies on the effects of the gluten-free diet

on the learning on autistic children in an applied behavioral analysis program. The three subjects on the gluten-free diet had an average age of 6.7 years and an average of 2.1 years experience in applied behavioral analysis.

Procedure

Rates of learning of five behavioral targets of three male participants, 6-months and 9-months after the start of the diet, were compared using a between-subjects and within- subjects analysis. The total number of attempts for the last five targets mastered following the 6-months and 9-months, on the gluten-free diet comprised the post-treatment scores for each participant.

Results

Study 4 used both between-subjects and within-subjects analyses to show additional enhancement of learning after 9-months on the diet. The between-subjects one tailed t-test compared the performance of participants after 6-months on the diet and after 9-months on the diet. Significant differences in scores were found when the two groups were compared ($t=.04$, $df=28$, $p<.05$). The mean number of trials to mastery at 6-months was 15.86, with a standard deviation of 13.22. The mean number of trials to mastery at 9-months was 5.87, with a standard deviation of 2.95.

The within-subjects one tailed t-test indicated a significant increase in the rate of learning following the implementation of the gluten-free diet ($t=1.99$, $df=14$, $p<.05$). The 9- month scores were significantly better than the 6-month scores, suggesting that additional time on the diet continued to enhance performance.

Discussion

The results of study 4 concur with the results of the three previous studies by indicating that a gluten-free diet is associated with continual improvement in the rate of learning on autistic children participating in an applied behavioral analysis program over a time period of 9-months. The dietary restriction of gluten may produce additional improvements over time, at least during the first year of the dietary exposure.

Further research should be done on the children at later times following the intervention. Regular evaluations need to be included in the gluten-free diet to see if further improvements develop over time.

Study 5

Summary Analysis

Methods

Subjects

Three autistic children, with ages ranging from five to eight years old, served as subjects. All subjects were also participants in the three prior studies on the effects of the gluten-free diet on the learning on autistic children in an applied behavioral analysis program. The three subjects on the gluten-free diet had an average age of 6.7 years and an average of 2.1 years experience in applied behavioral analysis.

Procedure

Rates of learning of five behavioral targets of three male participants, involved the number of attempts required to reach a

behavioral target during a pretreatment baseline, and at 9-months after the initiation of the gluten-free diet ,were compared using a between-subjects and within-subjects analyses. The total number of attempts for the last five targets mastered following 6-months and 9-months on the gluten-free diet comprised the post-treatment scores for each participant.

Results

Study 5 used both between-subjects and a within-subjects analyses to show if a significant performance change over the 9-month gluten-free diet period existed. Both the between-subjects and within-subjects one tailed t-tests revealed no significant increase in the rate of learning following the implementation of the gluten-free diet, over a 9-month period.

Discussion

The results of the first four studies in the series indicate that a gluten-free diet is associated with continual improvement on the rate of learning of autistic children participating in an applied behavioral analysis program over a period of 1-month, 3-months, 6-months, and 9-months. The dietary restriction of gluten seems to be associated with improved performance, and additional gains are observed over time.

However, the failure in study five to observe a significant performance change between the baseline and the 9-month diet period, using either the between or within-subjects analyses, raises questions about the reliability of this treatment's effectiveness. If the diet is associated with significant

improvement on rate of learning when evaluated from month to month, then why does it not show significant results when pretreatment baseline data is compared with the nine month posttreatment data? High variability in rate of learning within subjects may have accounted for the observed inconsistency across Studies I-V. Development of more reliable means of assessing the impact of the gluten-free diet on the potential for learning might clarify matters. Further research is needed to determine the long-term impact of the gluten-free diet on the performance of autistic children.

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